



2000

A Comparison Between Edema and Lymphedema

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A COMPARISON BETWEEN EDEMA AND LYMPHEDEMA

by

Janelle Sunnarborg
Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Physical Therapy

Grand Forks, North Dakota

May

2000



This Independent Study, submitted by Janelle Sunnarborg in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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Title A comparison between edema and lymphedema

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ACKNOWLEDGEMENTS

The following events spurred my interest in edema and lymphedema which led to this independent study. I set sail on a cruise to Alaska with many relatives in June of 1999 to enjoy love and laughter with my family and a time of relaxation. When returning home, my father complained of leg cramping and became sick. After the discovery of a “rash” on his lower leg that evening, I drove him to the emergency center where I sat nearly seven hours in the waiting room. The time for relaxation had ended and my father had to spend many hours in the hospital over the next three days receiving treatment for what many medical professionals called the worst case of cellulitis they had ever seen. The extent of swelling is best visualized with the memories of sock removal requiring much time and the use of all four of our hands, mopping down the hallway, through the kitchen, and each stair leading to our basement to clean the discharge from the open wounds, and the piles of laundry each day. These episodes inspired me to write this paper on the comparison between edema and lymphedema.

I want to thank my entire family, but most of all my father, Marshall, my mother, Joanne, and my brother and sister, Justin and Joellyn. I love you and thank you very much. You are my primary support system, filling my heart with much joy, many laughs, and big dreams, nearly all of which have come true. Mom and dad, thank you for my faith. The Lord has been my guide and has provided me with strength, especially the last

seven years of my post secondary education. Jesus never said life would be easy, but He said one will never have to walk alone.

Thank you Michelle LaBrecque for your many hours of reading and review. Your efforts in fine tuning this work have increased the effectiveness of my writing. In addition, the smiles which light your face and your positive spirit eased the arduousness of my task. Thank you to all the instructors in the Physical Therapy Department at the University of North Dakota who have increased my knowledge of this subject through classroom education.

Now that this independent study is completed it is time to relax once again. Anyone up for a cruise to Alaska?

ABSTRACT

The terms edema and lymphedema are often used interchangeably but treatment approaches for these forms of swelling differ. The purpose of this paper is to compare the treatments for edema and lymphedema, provide a background in the anatomy of the circulatory system and discuss signs, symptoms, and causes of swelling. Management of edema is directed toward its cause but physical therapy treatment may also be appropriate. Lymphedema remains a risk for years following initial injury, therefore, preventative measures are especially important to address, to decrease the occurrence of cellulitis.

Physical therapy treatment for edema and lymphedema include elevation, compression, exercise, electric stimulation, massage, thermal modalities, and hyaluronidase applied by iontophoresis. The approaches differ in the pressure applied, treatment time, form of wrapping, degree of stimulation and technique. Further research should be performed in the areas of thermal therapy for treating lymphedema, ultrasound for chronic edema and lymphedema treatment and use of human studies to enhance effectiveness of treatment.

CHAPTER 1

INTRODUCTION

The excessive accumulation of fluid that enlarges an area of the body or an increase in fluid that becomes permanent is termed edema which is derived from the Greek word for swelling.¹ The accumulation of fluid in a limb may be the result of an alteration in Starling's Law which states that the fluid filtered from capillaries is nearly equal to the fluid absorbed. The result is edema where the accumulation of fluid is so great that the lymphatic system is unable to return the proteins that have escaped from the capillaries to the blood. Lymphedema occurs when the enlargement is the result of malformation, malfunction or obstruction of the lymphatic system.

The lifestyle of an individual with a swollen limb may be compromised as the result of physical disabilities as well as psychological and social effects of an altered body image. The physical disabilities may be due to weakness, limited range of motion, stiffness, pain, or numbness. The psychosocial effects may include depression, anxiety, and a negative self-image.

As many as 70% of individuals who have axillary node dissection, the most effective breast cancer treatment, will develop upper extremity lymphedema. Inguinal node dissection may result in an incidence of lower extremity lymphedema as high as 12% but may be up to 69% when the pelvic nodes are dissected or irradiation is

performed to the inguinal and pelvic lymph node beds.¹ Over 50% of the instances of leg edema occur as the result of venous insufficiency and heart failure.²

The permanency of fluid is a concern when fluid is not reduced and organization of the fluid occurs.³ Edema usually diminishes with the treatment of its underlying disease but lymphedema cannot be cured. The effects of lymphedema may be minimized, through physical therapy treatment aimed at moving fluid between the skin and superficial fascia. Edema may require physical therapy as well, depending on the extent of the swelling. The reduction of edema occurs when circulation through the vascular system increases. Fluid reduction in the limb may occur through elevation, muscle contraction, modalities, massage, electrotherapy, hyaluronidase, and various forms of compression. All of these techniques have shown effectiveness in the treatment of edema and lymphedema. There is a distinction between management and prevention strategies for edema and lymphedema. The purpose of this paper is to provide a background in the anatomy of the circulatory system, discuss signs, symptoms and causes of swelling, and compare treatments between edema and lymphedema.

CHAPTER 2

ANATOMY OF THE CIRCULATORY SYSTEM

The Cardiovascular System

Five liters of blood circulates throughout the body every minute, transporting oxygen from the lungs and nutrients from the gastrointestinal tract to tissues.⁵ The cardiovascular system then transports the metabolic wastes to the kidneys and carbon dioxide to the lungs. The cardiovascular system also regulates body temperature and distributes hormones and other substances that control cell function.⁵

Blood is pumped from the heart through a closed system of blood vessels. After leaving the left ventricle, blood enters arteries, arterioles, and then capillaries. The blood equilibrates with interstitial fluid at the capillary level, where the exchange of nutrients, oxygen, and wastes occurs. Blood flows out of the capillaries into venules and then into veins where blood subsequently enters the right atrium. Blood that enters the body is termed systemic circulation and blood that enters the vessels of the lungs is termed pulmonary circulation. Cardiac output, arterial pressure, and the needs of tissues regulate blood flow through the cardiovascular system.⁶

The interstitium is the surrounding environment of all cells within the body, occupying the spaces outside the blood vessels.⁷ This extracellular space contains a watery medium known as interstitial fluid, which is similar to plasma except for the

presence of leukocytes and a significantly reduced amount of protein. Only a plasma membrane separates the interstitial fluid from intracellular fluid.⁸

According to Starling's hypothesis, there is a close balance between filtration of the capillaries and reabsorption from the interstitial fluid. Hydrostatic and osmotic pressures are the forces that determine the net filtration. Hydrostatic pressures occur as a result of water pressure in the fluids. Fluid tends to be pushed out of the capillaries because the blood hydrostatic pressure is near 17 mmHg and the interstitial fluid hydrostatic pressure is approximately -6.3 mmHg. The strength of the blood hydrostatic pressure varies, however, with changes in blood pressure and resistance within the blood vessels. When arteriolar smooth muscles dilate, the capillaries following these arterioles filtrate fluid. Absorption occurs with constriction of the arteriolar smooth muscles due to the decrease in capillary pressure. Osmotic pressures result mostly from the presence of plasma proteins. The majority of these proteins are too large to move through the capillary walls. The concentration of proteins in the plasma is almost four times that of the interstitium. The blood colloid osmotic pressure is approximately 28 mmHg, which tends to pull fluid into the capillary. The interstitial fluid osmotic pressure of 5.0 mmHg moves fluid into the interstitial space. The overall pressure of forces pushing fluid out of the capillaries and the forces pulling fluid into the capillaries favors a filtration of 0.3 mmHg, producing fluid excess known as interstitial fluid.⁴ When the pressure within the capillaries or permeability of the capillaries increases, when fluid is retained, or if plasma protein concentration decreases, edema will occur as a result of fluid accumulation in the

interstitium. This is generally not observable until interstitial fluid accumulation results in a 30% increase in volume.⁹

The Lymphatic System

Unlike the cardiovascular system, the lymphatic system does not function in a circuit.⁴ The lymphatic system consists of lymph, lymphatic vessels, lymph nodes, tonsils, the thymus, and the spleen.¹⁰ Lymphatic vessels resemble veins in that they are thin-walled vessels with one-way valves.⁴ Lymphatic capillaries begin as small passageways in spaces between cells and unite with other lymphatic capillaries to form larger lymphatic vessels.¹⁰ The two groups of lymph capillaries, superficial and deep, drain tissues. The superficial group drains the dermis which is the deep layer of skin that provides strength and flexibility. The superficial group also drains the hypodermis which attaches the dermis to muscle or bone.⁷ Lymphatic capillaries are not present in bone, tendon and cartilage.¹¹ Fluid from the muscles, joints, viscera, and deep structures other than bone, tendon and cartilage is removed by the deep group of lymph capillaries.⁷ The fluid of the superficial dermis drains into the deeper group, then into subcutaneous tissues, and subsequently to the lymph vessel trunks. From these large vessels, lymph is channeled through lymph nodes.¹¹

The lymph nodes including the tonsils, thymus, and spleen are all lymph organs.⁸ Lymph nodes are scattered in multiple groups throughout the body along the length of lymphatics. Foreign substances in lymph are filtered as they flow through these nodes. The lymph nodes contain phagocytic macrophages that engulf debris and bacteria.¹⁰ Tonsils are large lymph nodes aggregated at the oral cavity and pharyngeal junction.¹¹

The thymus is the site where T-lymphocytes mature. The large collection of lymphoid tissue in the spleen is the location of T-lymphocytes and B-lymphocytes, providing defense from foreign substances by filtering blood and trapping antigens.¹² The T and B-lymphocytes are also referred to as T cells and B cells. A cell-mediated defense occurs when T cells release cytotoxic substances which destroy foreign substances. The B cells are lymphocytes that differentiate into plasma cells.¹³ Plasma cells produce antibodies that destroy antigens for an antibody-mediated defense.^{10,13}

Once the interstitial fluid enters the lymphatic system, the fluid is called lymph. Lymph consists of clotting factors, lymphocytes, proteins, and water-insoluble fats, with lymph composition varying according to the location of the lymph within the body.⁵ Peripherally, the protein content in interstitial fluid is less than that found in blood plasma, with albumin being the primary protein absorbed from the capillaries.^{14,15} The permeable substances in lymph have a content comparable to plasma. However, more fat is present in the lymph within the abdominal region.¹⁴ Water-insoluble fats from the gastrointestinal tract are absorbed into the lymphatic system and transported to the blood.¹⁶

Since the concentration of protein in blood is much greater than that found in interstitial fluid, diffusion of protein back into the capillaries is not possible. The lymphatic system returns the protein from the interstitium to the cardiovascular system. The lymphatic system also helps maintain the gel consistency of interstitium by removing excess fluid.¹⁷ Lymph from the left side of the head, neck, chest, left upper extremity, and the body below the ribs enters into the thoracic duct.^{10,13} The beginning of the

thoracic duct is dilated and is called the cisterna chyli.¹³ The fluid in the thoracic duct enters the bloodstream where the left internal jugular vein and left subclavian vein join. The lymph from the right upper body flows into the right lymphatic duct. Lymph from the right lymphatic duct enters the bloodstream at the junction of the right internal jugular vein and the right subclavian vein.¹⁰ Approximately one-tenth of the excess fluid in the interstitium is drained through the lymphatic system rather than the circulation system.¹⁶

The flow rate of lymph is related to tissue activity and capillary permeability with an average of two to four liters of lymph flowing throughout the body each day.^{4,17} Lymph moves by large lymphatic contraction and the contraction of skeletal muscles.^{11,17} Tissue relaxation around the lymphatic vessels draws fluid into the vessels by expanding them with one-way valves maintaining the direction of flow toward the heart.¹⁰ Lymph movement is also improved with an increased velocity of blood flow through the venous system in the area where termination of the lymphatics occurs.¹⁸

Respiration also helps to maintain lymphatic flow by creating a pressure gradient within the lymphatic system.⁷ Inhalation increases the pressure near the abdomen and decreases the pressure near the thorax, causing lymph to move from the abdominal region to the thoracic region.^{10,13}

When the lymph transport capacity is reduced, the tissue proteolytic capacity decreases and the lymphatic load remains unchanged, a high protein edema occurs.¹⁹ Interstitial fluid begins to accumulate in the tissue spaces, a condition called lymphedema.

CHAPTER 3

SIGNS AND SYMPTOMS

Edema

A disruption in the physiology of a tissue from injury or disease results in edema. The body initiates an inflammatory reaction when injury occurs and although the same pathway is followed regardless of the etiology, different stages may be emphasized. The inflammatory process is divided into four responses which are controlled by neural and humoral mediators: a vascular response, a hemostatic response, a cellular response, and an immune response.²⁰

The vascular response is the initial stage, which begins with the transient vasoconstriction of arterioles.²¹ Leukocytes begin to line the walls of capillaries and venules, known as margination. Vasodilation then follows, increasing the blood flow and hydrostatic pressure. Gaps develop between endothelial cells, which increase the permeability of capillaries and venules. Cells, macromolecules, and fluid enter the interstitial spaces resulting in edema which can cause discomfort. The lymphatic vessels are ineffective in this situation as they are unable to reduce fluid in the area.²⁰ The fluid associated with edema changes from transudate, composed mostly of water and dissolved electrolytes, to exudate which is composed of protein and leukocytes, during the vascular response.²² Redness and warmth will develop due to vasodilation and pain occurs with bradykinin and prostaglandin production. Other vascular responses that occur include

release of histamine, bradykinin, prostaglandins, and other local mediators at the injury site.²⁰

The hemostatic response controls the loss of blood through ruptured blood vessels.²¹ Closure of small blood vessels is assisted by the retraction of the vessel walls. The aggregation and deposition of fibrin by platelets trap red blood cells and create a blood clot.²⁰ Local lymphatic vessels are occluded by fibrin to localize the inflammation.²³

In the cellular response, microorganisms are cleared from the area to allow for tissue repair. In early inflammation, phagocytosis of bacteria and cellular debris occurs by neutrophils since they are most predominant at this time.²¹ Digestive enzymes are released as neutrophils disintegrate, which irritate the tissues and act as chemotactic agents. Lymphocytes and monocytes are most numerous during late inflammation. Monocytes become phagocytic macrophages and engulf large amounts of bacteria and debris. Antibodies are produced by lymphocytes to mediate the immune reaction.²⁰

Cell-mediated and humoral responses make up the immune response. The response is characterized by the presence of lymphocytes, phagocytic leukocytes, as well as the complement system.²¹ The complement system is a series of enzymatic proteins that require bacterial toxins or immune complexes for activation. This cell-mediated response is found in many of the steps of inflammation including phagocytosis, increased vascular permeability, and chemotactic attraction by white blood cells.²⁰

In chronic edema, the cellular matrix is formed and remodeled by lymphocytes, monocytes, and macrophages.²⁰ An increase in formation of fibroblasts, collagen

production, and scar formation may be the result of unresolved acute inflammation, repeated microtrauma, persistent irritation from foreign material, or the contamination of an open wound.²³ Edema may cause adhesions in the joint lining or ligaments and decreased gliding of tendons.²⁴

Edema may result in the presence of many additional symptoms. General immobility and pain are often present with edema, and many times lead to a cycle of limb disuse and dysfunction.^{24,25} Edema is characterized by minimal swelling in the morning with swelling often increasing throughout the day, enhanced by the increased vascular hydrostatic pressure with gravitational forces. The interstitial cells have excess fluid due to the decrease in protein within the plasma, which produces generalized edema.² Generalized edema may result in multiple symptoms including shortness of breath, swelling of the lower extremities that diminishes when lying down, nocturia, reduced urinary output, orthopnea, weight gain, difficult, rapid, and shallow breathing, expanded neck veins with an elevation of the head to 45°, and altered venous and arterial blood pressures.²⁶ Edema may also be localized, usually characterized by unilateral swelling. Nonpitting edema may result from the coagulation of interstitial fluid or swelling in tissues as a result of disease, trauma, or inadequate nourishment. Stagnation for a long period of time changes the color of skin to golden brown, a condition known as brawny edema.²²

Lymphedema

In comparison, lymphedema is progressive with changes occurring in the skin and subcutaneous tissue, resulting in the loss of normal sensation.²⁷ The static fluid causes

pitting edema and deepens skin creases and folds.^{28,29} In the early stage, known as acute lymphedema, the swelling usually resolves after two weeks to three months and will often decrease when the extremity is elevated.^{18,27} Lymphedema that has been present for three months or more is considered chronic. In the chronic stage, stagnant fluid rich with protein triggers an inflammatory response which may produce redness.²⁷ Brawny edema may result from the damage of skin and subcutaneous tissues. The natural elasticity of the skin is lost and macrophage activity decreases.²⁸ The large accumulation of fibroblasts and collagen within the fluid results in connective tissue overgrowth, dilatation and thickening of lymphatic capillaries, and fibrous tissue replacing adipose tissue.¹¹ Tumor formation may also result from an insufficient lymphatic system.⁶

The enlargement of the limb leads to functional impairment and in many instances has psychosocial effects. Pain and discomfort from the increased pressure on nerves, heaviness, and the size of the extremity may decrease range of motion of the limb.¹⁴ The ability to perform activities of daily living decreases and mobility and independence may be lost due to the physical symptoms which include weakness and stiffness.^{14,27} Functional performance is also affected due to the psychological distress. Life becomes displeasing for many and compliance with treatment decreases. A significant number of women with lymphedema develop anxiety and depression secondary to the lifestyle changes. Women form a negative self-image which may result in decreased socialization.¹⁴

Chronic pain is common and occurs when an enlarged limb increases stress on joints. An example of this is pain in the shoulder, neck, cranium, and back resulting

from a swollen upper extremity. Joints may be painful due to the stress from the stretching of fibrous skin and tissue. Other sources of pain include infection, neuropathies, or muscle spasm.¹⁴

Skin changes occur as a result of the excess fluid, rich with protein.²⁹ The medium is ideal for bacteria, increasing the risk for recurrent, acute inflammation. A high fever, chills, and malaise develop suddenly as a result of infection.²⁸ The presence of moisture is also ideal for fungal infections.²⁹ Other skin changes that may occur are abrasions and weeping.²⁷

Physical characteristics are used in the division of lymphedema into three grades. In Grade I, pitting edema is present and the edema decreases with elevation. The plasma proteins remain stagnant, inflammation is chronic, and the edema becomes firm and nonpitting due to fibrosis and sclerosis in Grade II lymphedema. Grade III lymphedema is characterized by the overproduction of connective tissue, skin hardening, and lymphostasis elephantiasis.^{27,30} These grades are used to determine the degree of lymphedema progression in the limbs and do not apply to other areas of the body.²⁷

CHAPTER 4

CAUSES OF EDEMA AND LYMPHEDEMA

Edema occurs when a normally functioning lymphatic system is overwhelmed by an abnormally large amount of interstitial fluid and may be characterized as generalized or localized edema.²² Generalized edema occurs as a result of systemic changes, characterized by multiple symptoms, including the swelling of more than one extremity.³¹ Localized edema is the result of a change in the hydrostatic pressure or capillary permeability and is characterized by unilateral edema. Factors leading to edema include an increase in capillary hydrostatic pressure, permeability of the capillary wall or venous pressure or a decrease in the capillary oncotic pressure or lymphatic flow.⁹

Generalized Edema

The excess interstitial fluid present with generalized edema may be a result of a cardiovascular disease, renal disease, liver disease, pregnancy, drugs, generalized lymphedema, hypoproteinemic state, altered systemic capillary permeability, or idiopathic cyclic edema.³² Starling forces are altered, as with localized edema, moving an increased amount of fluid out of the capillaries and into the interstitium.⁴

There are many cardiovascular diseases that cause generalized edema. Congestive heart failure increases renal sodium retention and peripheral edema as a result of high-output or low-output of the heart.³³ Right ventricular heart failure, which results in an increase in end-diastolic pressure, raises the venous hydrostatic pressure and

decreases drainage from the interstitium. Renal sodium retention occurs, exacerbating peripheral edema accumulation.³⁴

Four groups of drugs produce generalized edema. These groups are estrogen or progesterone containing compounds and corticosteroids, antihypertensive agents, vasodilators, and nonsteroidal anti-inflammatory agents. All of these medications promote renal sodium retention.³⁴

Pulmonary hypertension results in peripheral edema due to decreased cardiac output and right-sided heart failure.^{32,33} Chronic constrictive pericarditis will increase venous hydrostatic pressure, thus decrease lymphatic drainage. An obstruction in the vena cava causes edema due to the increase in venous hydrostatic pressure and decrease in lymphatic drainage. Another cardiovascular disease that causes generalized edema is arteriovenous fistulae which promotes renal sodium retention and an increase in hydrostatic pressure.³³

Edema may be the result of hypoalbuminemia with protein-calorie malnutrition.² Protein loss may also occur with kidney or liver diseases since the body may not be able to produce enough protein or may lose a large quantity of protein. A reduction in the plasma proteins decreases the blood colloid osmotic pressure and results in excess fluid accumulation in the interstitial cells. Without protein to transport water out of tissues, water remains in the interstitium.¹

Several renal diseases result in peripheral edema due to the impaired sodium excretion and the renal loss of albumin which may decrease the plasma oncotic pressure. Acute renal failure leads to impaired renal excretion of sodium.³² The ability to

concentrate urine is lost in individuals with chronic renal insufficiency.³⁴ Edema may result if the intake of sodium is too great or the output of sodium is too low. Nephrotic syndrome is a renal disease causing edema due to the reduction in plasma albumin and the physiologic sodium and water-retaining state.^{32,34}

Liver diseases associated with peripheral edema include hepatitis, cirrhosis, chronic biliary obstruction, and hepatic venous obstruction.^{32,35} These conditions stimulate the kidneys to retain sodium. The impaired synthesis of albumin by the liver, which reduces the plasma oncotic pressure, and decreased peripheral lymphatic drainage add to the accumulation of peripheral edema.³²

Edema that is idiopathic and cyclic has no known cause. Edema may occur in women before the onset of menopause, however the symptoms are not related to the menstrual cycle. Usually obesity and a family history of diabetes are present.³²

During pregnancy, bilateral edema in the lower extremities is common.^{32,35} Much sodium is retained at this time causing the extracellular space to expand. The increased pressure from the uterus also causes an increase in peripheral edema. This pressure increases aldosterone secretion, venous capacitance, and venous hydrostatic pressure and decreases the peripheral resistance and the plasma oncotic pressure.³²

Increased systemic capillary permeability produces peripheral edema and may be present with diabetes mellitus, angioedema, and septic shock. The altered basement membranes of capillaries found in individuals with diabetes may result in diffuse microangiopathy and peripheral edema. Edema formation is increased with cardiac and renal diseases associated with diabetes which may exacerbate sodium retention and

increase edema. Angioedema is a result of histamine release, altering the systemic capillary permeability. Septic shock also increases capillary permeability.³²

Edema due to reduced plasma albumin may be a result of other diseases besides nephrotic syndrome and liver disease. Protein-calorie malnutrition may result in peripheral edema due to a low plasma oncotic pressure.² This malnutrition may occur following chronic alcoholism, malignant disease, malabsorption, protein-wasting enteropathy or psychological disorders related to impaired food intake.³²

Localized Edema

Altered Starling forces may also result in localized edema, with changes in hydrostatic pressure, capillary permeability, or lymphatic drainage.²⁹ This type of edema may be due to a vascular disease, deep vein thrombosis, lymphedema, lymphangitis, local changes in capillary permeability (such as with trauma or infection), an autonomic dysfunction, or be synovitis-associated.³²

Vascular diseases, such as venous insufficiency, deep venous thrombosis and vascular anomalies may cause edema. Edema in venous insufficiency is a result of varicosities. Deep venous thrombosis, the most frequent cause of venous obstruction, increases the resistance in venous blood flow, resulting in venous hypertension. This causes local inflammation which changes vascular permeability. Edema in venous insufficiency is a result of prolonged overstretching of veins which increases venous pressure and cause varicosities and incompetent valves.³⁶ Edema may also be a result of arteriovenous fistulae which may increase venous hydrostatic pressure and disrupt lymphatic drainage following surgery.³²

Local changes in capillary permeability may be a result of ischemic injury or local infection. Ischemic injuries including trauma, burns, surgery, atherosclerotic disease, systemic emboli, vasculitis, and severe infections increase the permeability of the capillary basement membrane causing protein to leak into the interstitium and increase fluid movement to the area. Cellulitis, often caused by streptococcal or staphylococcal infections, or lymphangitis increases capillary permeability causing edema.³²

Edema localized to an extremity may also be the result of autonomic dysfunction. Cerebrovascular accident or reflex sympathetic dystrophies may alter autonomic tone, affecting intravascular hydrostatic pressure and lymphatic drainage.³²

Lymphedema

Localized lymphedema may be primary or secondary. Primary lymphedema may be the result of an inherited disease, Milroy's disease, or may occur spontaneously or develop congenitally, occurring between puberty and the age of 35 years old (lymphedema praecox) or later in life (lymphedema tarde).^{11,28,37} The length of time before the lymphedema develops depends on the severity of the defect.¹ Primary lymphedema results in malformations, including hypoplastic, aplastic, or varicose and incompetent lymph vessels and cause lymph stasis. Flow may become bidirectional with fluid moving from the deep to the superficial lymphatic vessels.¹¹

Secondary lymphedema occurs when trauma to the lymphatics result in malfunctioning of the system, as seen with filariasis, a parasitic infection, or recurrent infection and inflammation.^{38,39} Cellulitis and lymphangitis are the two most common inflammatory conditions which may occur in conjunction with infection.³⁹ Secondary

lymphedema may also be the result of an obstruction of the lymphatic system following surgery or localized radiation therapy or it may occur with metastases, granulomatous diseases, or synovitis.³²

Lymphatic flow obstruction may also result in generalized edema when lymphatic drainage is decreased in more than one extremity. The most common cause of generalized lymphedema after the age of 40 is malignancy. When lymph flow is decreased, a high concentration of protein within the interstitial fluid results, drawing more fluid into the interstitium and creating lymphedema.³²

CHAPTER 5

TREATMENT

To convey the presence of swelling, the words edema and lymphedema are frequently used interchangeably.⁴⁰ However, it is important to differentiate edema from lymphedema as the treatment approach is often different.

Many treatment techniques for lymphedema and edema have been studied including thermal modalities, elevation, muscle contraction, and compression. Most of these are used to increase blood and/or lymph flow to reduce the swelling through the application of pressure. Treatment of edema is directed at the cause but many techniques have been used in physical therapy to decrease its presence and its possible effects.³² Treatment of lymphedema focuses on controlling, not curing, the swelling.⁴⁰

Physical therapy treatment techniques for edema date back to the nineteenth century. In 1855, conservative therapy measures for lymphedema included proper hygiene, use of compression and elevation prior to surgery. In 1892, there was the belief that in addition to these measures, bed rest, massage and exercise should be used to control the swelling. The cause of lymphedema may not have been known at this time since venous obstruction was suggested as the primary cause for swelling following radical mastectomy in the mid 1900's.³⁰

Elevation

One historical conservative measure that continues to be used today is elevation of the limb, which increases the venous and lymphatic flow within the extremity. Elevation will decrease the blood pressure in the limb by reducing the pressure on the arteries with a minimal effect on venous pressure. The hydrostatic effect is the actual cause of improved flow in peripheral vascular disorders.⁴¹ The hydrostatic pressure increases the thoracic blood volume and reduces the lower limb blood volume when a body lies supine from standing, increasing the venous return.³ It is believed that gravity may help to normalize lymph flow as well.²¹ The proximal limb should be lower than the distal limb and the heart even lower to encourage flow.³ Lymph flow increases as the limb is elevated to a higher degree.²¹ Generally reduction in the size of the limb is not noted with lymphedema but will occur with edema caused from venous involvement.^{2,41} When used with no additional treatment approach, rest and elevation may not be effective.⁴² Fluid will flow to the root of the limb, the location where lymph nodes are blocked, and will remain at this site until drainage occurs into the trunk.⁴⁰

Muscle Contraction

Muscle contraction minimizes edema and lymphedema by compressing venous and lymphatic vessels, increasing fluid movement proximally.^{10,43} Since muscles are contained within the skin and fascia which house the lymphatics, this sheath provides the pressure required for lymph movement. When the edema is severe, additional support is required due to the loss of skin and fascial elasticity.⁴³ Many capillaries are opened up with muscle contraction, which enhances blood flow to the heart.⁴¹ Muscle relaxation

decreases the pressure within the venous and lymphatic vessels allowing them to refill.⁴³ Active exercises, electrically induced muscle contraction, and perhaps isometric exercises improve fluid flow.^{18,21} Heavy impact activities should be avoided due to the possible increase in vasodilation and blood flow, producing even more lymph.⁴⁰ It has been suggested that isometric exercises may have this same negative result.⁴⁴ Sudden pressure changes which occur in weight bearing activities may release endothelial-derived relaxing factor (EDRF). Smooth muscles relax as a result of EDRF and blood flow through the veins is increased.²¹ When exercising, respiration becomes more rapid, facilitating an increase in venous return.⁴¹ Diaphragmatic breathing exercises use the thoracic pump to reduce edema and lymphedema of the lower extremities.⁴⁰ The movement of fluid primarily occurs with inhalation when the abdominal pressure is increased and the intrathoracic pressure is negative.¹⁰

Many studies have been performed on frog hind limbs to determine whether lymph and blood flow is increased by electrical stimulation. Low voltage pulsed current, symmetrical biphasic pulsed current, and anodal high voltage pulsed current (HVPC) have been shown to have no significant treatment effects.^{45,46,47} When HVPC is used at intensities above that which induces muscle contraction with continuous stimulation, a muscle-pumping effect is created by compressing venous and lymphatic vessels. Treatment results may be influenced by a reduction in the permeability of proteins across the capillary wall, polarity, and a decrease in the capillary pressure.^{48,49} Several of the studies describing HVPC used voltages 10% less than that evoking muscle contraction and a frequency of 120 Hz.^{48,50,51} Edema formation was decreased, but this effect was

noted to occur only during the actual treatment or up to seventeen hours following treatment.^{48,50} Electrically stimulated lymphatic drainage (ESD), with an elastic sleeve application between treatments, in 4.5 KHz pulses at an intensity of patient's maximal tolerance without discomfort reduced the limb circumference by 17%. However, there was no significant difference in results between this group and the group of subjects wearing only an elastic sleeve.⁵²

External Pressure

Various forms of external pressure also help to increase lymph and blood flow and enhance the pumping action muscle contraction creates, including massage, elastic compression and intermittent pressure. The application of a mechanical force is termed compression which improves fluid balance and circulation. This force causes movement of the fluid from the interstitium into the blood vessels. This increases the flow from the interstitium into the capillaries and limits the flow of the interstitium into the lymphatic vessels.³⁸

Massage increases venous circulation by using deep strokes of effleurage and petrissage toward the heart working distally to proximally. Fibrous tissue is stretched with massage, aiding in swelling reduction.⁵³ Although many studies have shown this type of massage to be effective in lymph removal, this may result in damage of tissues, increasing the swelling further. Positive effects of massage with lymphedema include the loosening of connective tissue, the formation of channels to drain lymph, and the increased movement of lipid droplets into the lymphatic system if accumulation of fat and fibrous tissue in the interstitial fluid has occurred.⁵⁴

Manual lymph drainage (MLD) refers to a gentler, more superficial massage for treating lymphedema. When removal of nodes or obstruction of drainage by the lymph glands is present, lymphedema is often noted in that region.⁴⁰ In this situation, lymph flow must first be increased in the contralateral trunk. Fluid should then be massaged from the truncal quadrant adjacent to the limb into the unilateral or contralateral quadrant.⁴² This creates an alternate lymphatic drainage pathway by allowing superficial lymph to drain to deep lymphatics and then through intact nodes in the opposite axillary or inguinal region.^{1,40} This also prepares these intact lymph nodes to accept additional fluid.⁴⁰ Proximal limb massage is then performed followed by distal to proximal massage. In the lower extremity, if movement of the lymph does not start proximally, the lymphedema will be moved towards the groin and swelling of the genitalia will result.⁴² MLD begins at the neck when treating the upper limb since there may be a blockage at the junction of the lymph system with the venous system.¹ These techniques are also important since there is decreased success in treating genitalia, the neck, and the head.⁵⁵ This form of treatment is used by health care professionals who advocate the most conservative therapies.¹⁸

Five basic strokes aid in increasing lymphatic flow by MLD. These include the turning stroke, used over large surfaces such as the trunk; a pump stroke and a dip stroke, both used to drain the extremities; a standing circle over the lymph nodes; and a pump stroke and standing circle combination.¹ Each stroke is repeated five to seven times in the affected area which allows time for lymph to respond.^{1,18} The pressure of each stroke should move only the skin and be in the direction of lymph vessel flow. The pressure

duration should be at least one second with a gradual release of pressure. A relaxation period, shorter than the period of time pressure was applied, should occur.^{1,18} No pain or redness should result from the gentle strokes.¹

Compression garments, generally made of Lycra spandex and nylon, are effective for a limited time when treating edema but may not be useful if the individual is noncompliant and/or has thighs that are disproportionately large.^{2,38} Edema is dispersed and the hydrostatic pressure of the interstitial fluid is increased with compression. The movement of fluid out of the capillaries is decreased since the change in hydrostatic pressure counteracts some of the force. In most ambulatory patients, a pressure of 30 to 40 mmHg is sufficient in controlling edema. A lower pressure may be adequate if the edema is mild and severe cases of edema may require a garment with greater pressure.³⁸ Compression stockings are most beneficial for edema due to heart failure but are also effective for edema caused by venous insufficiency, end-stage liver cirrhosis, and severe renal insufficiency.²

Compression by elastic stockings is beneficial in reducing and sustaining a decrease of fluid with lymphedema but to a lesser degree than with venous edema. This compression is required in treating lymphedema in order to support the hydrostatic pressure of the tissues. It is recommended that the stocking pressure be between 40 and 50 mmHg with stocking replacement every six months due to decreased effectiveness of the garment.⁴⁰ In cases of mild or recent onset of lymphedema, a compression sleeve with a pressure of 30 to 40 mmHg and sleeve renewal between three and four months is

recommended.⁵⁶ Gentle exercises while wearing the containment garment activate the pumping of the venous and lymphatic systems, improving drainage of the excess fluid.⁴⁰

Bandaging may be more beneficial in lymphedema treatment than compression sleeves or stockings if the limb is uneven and awkward in shape. Initially, bandaging may provide the increased compression needed before elastic stockings or sleeves are used. Highly elastic bandages would stretch with muscle contraction and not increase the pumping of lymphedema. Instead, low stretch, non-yielding bandages, such as Secure Forte or Setopress are used, resulting in increased pressure and lymphedema movement with contraction of muscles. The limb is first lined with a bandage such as a stockinette or Tubifast to protect the skin through the absorption of sweat. A glove, finger bandage, or toe bandage may also be used if needed. In order to distribute the pressure and prevent slipping of the compression bandage into the joint creases when exercising, padding is used around the joints or the entire limb. The 1/4-inch foam, Velbande, orthopaedic padding, or gamgee tissue that is used for padding also improves application of the outer bandage due to its cylindrical shape. The compression bandage reduces lymphedema by overlapping 2/3 of the previous layer in the distal portion of the limb and overlapping by 1/2 in the proximal portion.⁴⁰ Another source states this spiral wrapping is not recommended and a figure eight wrap should be used instead to avoid uneven pressure.³⁸

Bandaging has also been applied to decrease edema of venous origin but the application of a compression bandage during acute inflammation in order to reduce edema have not been statistically significant.⁵⁹ The application of soft cotton absorbs the sweat and cohesive gauze or foam prevents the bandage from slipping. The pressure of

the bandage should be enough to provide a moderate, comfortable compression without the impairment of circulation. The spiral wrapping is not recommended in the treatment of edema since the pressure may not be applied evenly. The figure eight wrap, with pressure beginning distally and moving proximally, should be used. A low-stretch bandage which provides 30 to 90% extensibility is fairly effective when the limb is active or at rest. A bandage providing more stretch would impair circulation when the limb was inactive. Bandages with no elastic are advantageous when exercising but are not effective in controlling edema in a flaccid or inactive limb.³⁸

Treatment using intermittent pneumatic compression (IPC) tries to mimic massage strokes. Intermittent air is pumped through sleeves applied to the swollen limb causing pressure to reduce edema.⁵⁸ With the single-chamber sleeve or the preferred multichamber sleeve a temporary reduction of swelling occurs. When pain is severe enough to restrict movement of the extremity by the patient, IPC may serve as a substitute for the pumping action of muscles.^{24,59} Water is pumped away from the area, but the proteins remain.⁴⁰ Results of IPC include nonpitting edema converting to pitting edema, reduction of skin tightness, which decreases the level of pain, and warming of the cold, cyanotic appearing limb with change of color to near normal.^{24,60} Edema and lymphedema will occur between treatments without the use of an elastic stocking.⁶¹ Movement of fluid is more effective in the distal limb than the proximal limb in lymphedema. If limb root edema is present, compression pump use should be avoided due to the further increase in congestion at the root of the limb that would develop.⁴⁰ Edema that results from injury is not significantly decreased with the use of IPC.²¹

Reabsorption of edema and lymph movement may occur with pressures above 30 mmHG, the approximate arterial capillary pressure.⁵⁸ The pressure should not exceed systolic blood pressure, since this will cause arterial blood flow to cease. As a result of this decrease in blood flow, a painful tissue response may occur. Lymph is forced through lymphatic vessels at a pressure of 30-40 mmHg. Interstitial fluid will reenter the blood flow with a pressure between 40-50 mmHg.²¹ Numerous pressures for IPC have been researched and still no standards exist for optimal pressure, length and/or frequency of treatment.¹⁴ It is best to check with the patient's physician as to what pressure is recommended prior to treatment. On and off time sequences are variable, ranging from 30 seconds on and 30 seconds off to four minutes on and one minute off. Shorter on-off time sequences when treating lymphedema and longer on-off time sequences to increase the hydrostatic pressure for the treatment of venous edema may be most advantageous, however, these are not based on research. Although limb volume is decreased following compression for 30 minutes, lymphedema treatment usually lasts 3-4 hours. Ten to thirty minutes is often adequate to reduce edema unless the volume is overwhelming or resistant to treatment.²¹

Thermal Modalities

Thermal modalities are also used in the treatment of edema. In the acute stages, the initial 24 to 48 hours of inflammation, cold is commonly used to decrease the metabolic rate, cause vasoconstriction, reduce swelling and decrease leukocyte counts.²³ Caution must be taken as cold may increase inflammation while it is applied or as the tissues reheat following the cold treatment.⁶² The type of chemical mediator involved in

this reaction to the cold may involve the aggravation of prostaglandins. Heat during this acute time frame would further irritate the area, increasing edema formation and slowing recovery time.²⁰ Contrast baths are believed to cause vasodilation with heat and vasoconstriction with cold, creating a pumping action to remove fluid. However, cold is the most appropriate of the three therapies during acute inflammation.⁶³ Mild superficial heat may be used prior to stretching in subacute or chronic edema to overcome adhesions that have formed in the connective tissue. Reabsorption of exudates and debris that occur in late inflammation is assisted by the increase in blood flow associated with heat.²⁰ Although hot packs have been shown to increase lymphatic movement, a study exposing dogs and cats to extremes in temperature failed to show heat and cold to be beneficial in treating lymphedema.^{18,64} The amount of lymph increased with heat, possibly as a result of an accelerated rate of capillary filtration, but the percent of protein in the lymph decreased. The cold decreased lymph flow slightly and increased the percentage of protein. However, this change was not significant.⁶⁴ Heat applied by microwave diathermy, shortwave diathermy, fever cabinets, and infrared radiation have not shown significant alteration in lymph flow.⁶⁵ The use of thermal therapy to treat lymphedema is still under investigation.

Mechanical energy using ultrasound may be continuous or pulsed, both providing instant heat. Only continuous ultrasound sustains heating over a prolonged period of time. The heat of ultrasound will increase blood flow and collagen extensibility. Nonthermal effects of cavitation, which produce bubbles, and microstreaming, leading to localized fluid flow around the bubbles, are present with continuous and pulsed

ultrasound.⁶⁶ Both effects aid in the acceleration of the inflammatory phase with stimulation of histamine release from mast cells. Caution must be given since inflammation may increase if too high a dose is given and without the removal of the inflammation stimulus, poor results occur. The use of ultrasound is questionable with chronic swelling, and there is no research to show ultrasound is effective in treating lymphedema.⁶⁷

Hyaluronidase

The enzyme hyaluronidase reduces edema and lymphedema when it is administered by iontophoresis.⁶⁸ Hyaluronic acid is a mucopolysaccharide gel present in interstitial tissue and is hydrolyzed by hyaluronidase. A physical barrier against foreign substances is created by hyaluronic acid. When hydrolyzed, the interstitium becomes less viscous, increasing the rate at which interstitial fluid is diffused and absorbed into the circulatory system.⁶⁹ There is reluctance to administer hyaluronidase by injection due to the decreased resistance to infection but absorption of the enzyme may occur through the skin and subcutaneous tissues by iontophoresis. Edema that occurs as a result of trauma is rapidly decreased with hyaluronidase. Swelling is also reduced by this enzyme when lymphedema is the cause but this decrease in size is not permanent.⁶⁸

Consistent levels of increased success are found in the multidimensional approaches with the names of complex physical therapy (CPT), complex decongestive therapy (CDT), complex lymphedema therapy (CLT), and complex decongestive physiotherapy. Treatment includes proper hygiene, manual lymph drainage, bandaging,

and exercises while bandaged.^{14,42} Many other combined treatment procedures have shown success as well.^{44,55,70,71}

Management and Prevention

Management of edema is directed toward its cause so the patient should become aware of the diagnosis, signs and symptoms, and risk factors. Strategies to avoid friction which would result in the development of a pressure ulcer, information on nutrition and treatment methods to reduce the swelling are the aims of patient education.^{18,26} The patient should be educated in compression stocking application and use, the importance of bedrest, elevation and exercise.²⁶ A patient's diet should be high in protein (most effective for patient's with edema caused by malnutrition) and calories, low in salt, and rich in vitamins.^{2,72} Leg crossing or any other position that would increase pressure on the blood vessels should be avoided. If an increase in limb swelling is noted by the patient, the physician or nurse should be notified.²⁶

The patient should receive information and become educated on lymphedema prevention measures since those who are knowledgeable and become active participants in their treatment have better control of their lymphedema and an improved lifestyle.¹⁴ An understanding that the risk for lymphedema is still present years after the initial injury to the lymphatic system must be achieved.⁷³ Tight clothing, including elastic cuffs on blouses or jewelry that may prevent lymph flow should not be worn. If the upper extremity is affected, a purse or heavy object should be carried using the opposite arm.⁵⁶ Daily skin care should be emphasized with lymphedema to prevent cellulitis. The skin should be moisturized with a perfume free lotion to prevent cracking.⁴⁰ An opening in

the skin can be an entry site for infection and activities that may break the skin should be avoided. Insect repellent should be worn to prevent bites and stings.⁵⁶ Sunburns and burns should be avoided, aided by the use of sunscreens and oven mitts.^{18,56} The patient should avoid extremes in temperature. Heat, as from a hot bath, reaching into a hot oven, or the use of a hair dryer may augment swelling from an increase in circulation.¹ The limb should be elevated 45° and abducted when the patient is sedentary and prolonged periods of standing and sitting should be avoided.^{1,18} A low fat, low salt, and high fiber diet should be encouraged to decrease fluid retention and the patient should be made aware that gaining weight and obesity may be associated with a negative recovery.¹⁴ By wearing gloves when gardening, cutting meats, and/or dishwashing or by using a thimble while sewing, protection is gained from trauma.^{1,18,56} Resisted and repetitive movements such as pushing, pulling, and scrubbing should be avoided.¹⁴ Shoes protect the extremities and should be worn when ambulatory. An electric razor with a narrow head is advisable as it decreases the risk of injuring the skin.¹⁸ A compression sleeve must be worn when flying with additional bandages for longer flights.¹⁴

The patient should be instructed in numerous areas of education and prevention specific to the patient's work environment. At work it is important that the extremity is not overtired and if lymphedema of an upper limb is present, lifting over 15 pounds should be avoided.¹⁴

Health care professionals must be careful when handling patients with edematous tissue and should follow preventative guidelines as well.⁷² Since skin has been stretched and the blood supply has been reduced, it is important to maintain skin integrity with

patients.²⁶ Friction must be avoided when turning, positioning, or transferring a patient.⁷² A pressure ulcer may develop as a result of a break, an abrasion or prolonged positioning of the edematous tissue.²⁶ Prescribed practices include taking blood and blood pressure from the unaffected arm and avoiding skin irritation due to injections. Exercise treatment should include walking, light aerobics, bicycling, swimming, or ballet or yoga specially designed for the patient to avoid overtiring the extremity. Patients should be referred to support groups and monitored for the need for counseling if emotional and social adjustments are not adequate.¹

When treating lymphedema, the definition, risk factors, etiology, signs and symptoms, reduction measures, and protection guidelines should be reviewed with the patient. In case an injury to the skin occurs, a description of the appropriate response should be given.¹⁸ The area should be washed well with soap and water, dried gently but thoroughly and then covered.^{14,18} The patient should be instructed to watch for signs of early detection of cellulitis including redness, warmth, or swelling and to notify the healthcare provider if these are present.¹⁸ Treatment to prevent the spread of infection should be administered by the physician immediately.⁴³ The patient should be referred to resources including the National Lymphedema Network, Susan G. Komen Breast Cancer Foundation, American Cancer Society, or the National Cancer Institute.¹⁸

CHAPTER 6

CONCLUSION

Edema and lymphedema must be differentiated from one another due to the physiological changes which occur with each. In edema, the lymphatic system is unable to return the proteins at the rate they are entering the interstitial fluid. Lymphedema occurs when swelling is the result of the malformation, malfunction or obstruction of the lymphatic system.

Edema and lymphedema may be treated with various physical therapy strategies but the approaches differ. Compression stocking pressure, technique of bandaging, and pressure and time sequences used with intermittent pneumatic compression are different. Active exercises and diaphragmatic breathing exercises minimize edema and lymphedema and electrical stimulation may be effective. Massage improves circulation whereas manual lymph drainage is gentler and more superficial for the movement of lymph. Cold is the most effective thermal modality to reduce acute swelling of venous origin whereas mild superficial heat is used in the treatment of subacute or chronic edema. Past studies have not shown lymph flow to change significantly with the application of cold or heat but research continues in this area. Hyaluronidase, applied by iontophoresis, is effective in reducing edema and lymphedema.

Further research is needed in the area of treatment methods for edema and lymphedema. More human studies should be performed since animals were used in much of the research, especially in treatment using electrical stimulation. Additional studies should be done in the area of thermal therapy for treating lymphedema and the effectiveness of ultrasound in the treatment of lymphedema and chronic edema. More comparison studies may be performed to determine the most effective means of treating edema and lymphedema in order to enhance the lifestyles and management of individuals afflicted with these conditions.

It is imperative that swelling is differentiated due to the differences between the physiological process, treatment approach and management of the condition. Only when this occurs will a patient reach the optimal outcome when afflicted with edema or lymphedema.

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